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Publication date:
2013

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ABSTRACT

Contrary to the tensile strength of uni-directional fibre reinforced polymers which to a great extent is controlled by the strength of the fibre material, the compression strength is controlled by other factors such as fibre misalignment and the polymeric matrix materials yielding behaviour. Therefore, improving the tensile strength of a composite material will not automatically lead to an improved compression strength. Carbon fibre composites for example have a compression strength typically only 50-60% of the corresponding tensile strength. One important application of composite materials is in wind turbine blades where more cost effective wind turbines until now has required an up scaling of the wind turbines with wind turbine blades approaching length of up to 80m. For long and slender structure like this, the design limits for the structure will increasingly be given by the compression strength of the material both regarding static and fatigue loading.

The material compressive failure mechanism of a composite involve kink-band formation which involve large rotation of the load carrying fibres and shear loading of the matrix material involving large local strains and plastic deformation. Therefore, in order to make proper simulation of the compressive failure mechanism in composites, it is necessary to take these effects into account. One approach [1] is to model the actual fiber/matrix system using a micromechanical based finite element model. Nevertheless, a wind turbine blade will include such large numbers of fibers making it unrealistic for a numerical model. In addition, such a model will including an extremely great deal of unwanted details. An alternative is to base the simulation on a smeared out composite model [2] where the nonlinear properties of the constituents are taken into account.

A numerical finite element implementation [3] has been used incorporating such a model in the commercial finite element code Abaqus. Nevertheless, such a smeared-out non-linear composite law does not include length scales from the underlying microstructure of the materials. Therefore, the localized kink-band solution obtain will be mesh dependent where the width of the kink-band will be given by the mesh size. In the presented work, the consequence on the predicted compression strength is investigated.

Acknowledgements: This research was supported by the Danish Centre for Composite Structure and Materials for Wind Turbines (DCCSM), grant no. 09-067212, from the Danish Strategic Research Council (DSF).

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